1010300

PATENT SPECIFICATION

DRAWINGS ATTACHED

1010300

Date of Application and filing Complete Specification Jan. 21, 1963.
No. 2595/63.

Application made in France (No. 885917) on Jan. 25, 1962.

Complete Specification Published Nov. 17, 1965.

Index at acceptance:—F1 T(B2B3, B2B4, B2C)

Int. Cl.:—F 01 d

COMPLETE SPECIFICATION

Elastic-Fluid Turbines with Multiple Casings

We, SOCIETE RATEAU, a French Body Corporate, of 40 rue du Colisee, Paris, Seine, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to elastic-fluid turbines having multiple casings.

For the construction of turbines, particularly steam turbines, which are required to withstand high pressures and often at the same time high temperatures, the advantages of a mode of construction using multiple casings one within the other are well known. In this mode of construction a single very thick wall is replaced by a series of very thin walls each of which is subjected only to a fraction of the total pressure difference between the interior of the turbine and the exterior thereof. This arrangement permits of more secure sealing of the housing, the sealing of the successive casings being easier to effect, and of limitation of the mass of metal subjected to the high internal temperatures by forming between the casings layers of fluid the temperature of which is controlled. Moreover, the small thicknesses associated with the said layers opens up the possibility of the temperature of the housing rising rapidly without developing excessive thermal stresses, this being an important factor in the versatility of the machine.

Figs. 1 and 2 of the accompanying drawings illustrate a conventional form of such an arrangement. Fig. 1 shows in longitudinal section a steam turbine the housing of which is constructed in accordance with the double casing principle and comprises therefore an internal casing *Ci* and an external casing *Ce*. These two casings are to be seen in Fig. 2 which shows the same machine in transverse section on the line 2—2 of Fig. 1, and in this figure can be seen the bolted parts B of the internal casing, the provision of which is imposed by the selected nature of mode of assembly. This is in fact a machine with a horizontal joint wherein the procedures of assembling and dismantling are based on the existence of a plane of section passing through the axis of rotation of the turbine and including all its fixed parts.

The bolted portions B present a number of problems. In the first place, their bulkiness is reflected in the dimensions of the external casing; further, owing to their proximity to the internal parts of the machine where the steam works they may be exposed to a high temperature. It will be appreciated that the difficulties are more acute when the pressure and temperature levels at the entrance to the turbine calls for a triple casing construction, but they are essentially localised, being associated with the said bolted parts of the innermost housing.

In accordance with the invention there is provided an elastic-fluid turbine having an internal casing in one piece enclosing at least the first stages of the turbine and at least one external casing, the stator blades of the turbine being supported in the internal casing by diaphragms each made in at least two sections and mounted in a system of keys which prevent rotation of the diaphragm in the internal casing, each diaphragm being mounted for free expansion in the radial direction and at least one diaphragm bearing in the axial direction against a first ring placed within the internal casing and surrounding the next rotor disc and stator diaphragm downstream, the said first ring bearing in turn against a second ring against which the diaphragm which the said first ring surrounds bears, and the second ring bearing against an abutment removably mounted in the internal casing.

[*Price* 4*s*. 6*d*.]

The external casing is preferably made in two parts joining in a diametrical plane extending axially of the casing.

The invention will now be more fully described with the aid of examples illustrated in the remaining figures of the accompanying drawings, in which

Fig. 3 is a vertical half-section through the axis of the initial stages of a steam turbine and an internal casing surrounding them,

Figs. 4 and 5 are transverse sections on the lines 4—4 and 5—5, respectively, of Fig. 3 on a reduced scale, the line of section of Fig. 3 being shown as 3—3 in Fig. 4,

Fig. 6 is an axial half-section on a larger scale of an alternative mounting of the nozzle ring of the first stage,

Fig. 7 is an axial half-section of an alternative construction of the sealing means at the upstream end of the rotor shaft of the turbine,

Fig. 8 shows the first stages of a steam turbine with a triple casing, seen in horizontal axial half-section, along the line 8—8 of

Fig. 9, which is a part view in section on the line 9—9 of Fig. 8,

Fig. 10 is a vertical half-section through the axis of the said first stages, along the line 10—10 of Fig. 9.

The steam turbine, the initial stages of which are shown in detail in Figs. 8, 9 and 10, comprises a rotor A with axis XX^1, of which only the rotor discs of the initial stages, such as R are illustrated. These rotor discs carry the moving blades *m*. The fixed stator blades *f* are carried by diaphragms D which are fixed, as will be seen later, to the internal casing E which is open at its downstream end. The internal casing E is enclosed in successive casings such as E^1 and E^{11}, which also enclose the subsequent stages of the turbine located to the right of Fig. 8. The steam is admitted by radial orifices such as O into an annular cavity T formed in known manner in the internal casing, and it leaves at C to perform work in the subsequent stages of the turbine. This steam leaving the space C in the internal casing expands over the whole space C_1 included between the innermost casing E and the next casing E^1.

Fig. 3 illustrates in longitudinal section a first embodiment the transverse section 4—4 of which is shown in Fig. 4. It will be noted that the casing E is circular and is a body of revolution with respect to the axis of the machine. The steam is admitted to an annular cavity. Through a plurality of radial orifices such as O.

In conventional manner each expansion stage of the turbine consists of a diaphragm such as D carrying the fixed stator blades *f*, and a rotor disc such as R the moving blades *m* of which receive impulse from the steam expanded in the fixed blades. Each of the diaphragms such as D contained in the casing E is constructed, as shown by Fig. 4, in two half-pieces D^1 and D^{11} which are symmetrical with respect to the horizontal plane passing through the axis XX^1 of the turbine; it will be seen later how this arrangement is imposed by the conditions of assembly. Since a diaphragm in direct contact with the motive fluid reaches its normal operating temperature more rapidly than the casing E, it is necessary that it should be capable of free expansion whilst retaining, for obvious mechanical reasons, the coincidence of its centre S with the axis XX^1 of the turbine. With this object four keys H each located at an end of one of the orthogonal diameters X_1—X_1 and X_2—X_2 of the diaphragm guide its thermal expansion; these keys are held in position by a finger K fixed in the casing E. Account has also been taken of the axial thrust of each diaphragm, resulting from the difference in the pressures acting on their upstream and downstream faces; this thrust causes the diaphragm D to bear against a continuous circular ring I which encloses the diaphragm D_3 which itself bears against a ring I^1. The assembly of the rings I associated with the successive stages ensures the transmission of the thrust of the diaphragms to a final abutment F located in the casing E and constituted for example by a ring formed from a plurality of sectors held by a ring M fixed on the last ring I^1 by screws M^1.

The rings I avoid a difficulty which would arise if the diaphragms bore directly against one another. In fact, each of them would then be subjected to the sum of the thrusts of the diaphragms located upstream and its free expansion would then be obstructed by considerable friction. Moreover, by preventing direct contact with the casing E of the steam that flows at high speed through the turbine these rings act as thermal screens that limit the flow of heat that penetrates into this casing, and consequently limit permanent or temporary thermal stresses.

It is clear that there should be some play at the periphery of the rings I so as to permit of their assembly and to make them function efficiently as thermal screens. But at the same time steps must be taken against leakages that could occur due to this play, after the first rotor stage, by finding a way out through the holes through which the fingers K pass through the ring I_2. The required sealing is ensured by means of sealing rings W of known type surrounding the fingers K and may be improved by locating sealing segments or rings Q at the periphery of the ring I_2.

It will be understood that although not

illustrated completely in the drawing the fixing and sealing devices of the other diaphragms such as D_3 and D_s and of the other rings such as I_s also the sealing segments of the last ring I^1 are the same same as those just described.

The sealing between the shaft A of the turbine and the diaphragms such as D is ensured in known manner by sealing rings A2 fixed to these diaphragms and co-operating with grooves A_1 formed in the periphery of this shaft.

The pressure existing in C_1 at the exterior of the internal casing E is, as already indicated, equal to the pressure at which the steam emerges from the last rotor stage contained in this casing, so that considerable leakage tends to occur along the shaft A from the first rotor stage towards the exterior, and this calls for the provision of a fairly long seal G carrying a large number of sealing rings A3 co-operating with the grooves A_1 of this shaft. This sealing ring G, as shown in Fig. 5 which is a transverse section on the line 5—5 of Fig. 3, is made up of two half-pieces G^1 and G^{11} which are symmetrical and have a diametrical plane of joining and are mounted for free expansion in accordance with a principle similar to that of the diaphragms. In the two planes a—a and 5—5 the ends of two orthogonal diameters of the sealing ring G are held by keys such as N and N^1 fixed by means not illustrated and permitting the sealing ring G to expand freely in radial directions. In addition, the action of pressure forces the sealing ring G against an abutment surface P on the casing E.

The nozzle blades f_1 of the first rotor stage may be made in a plurality of monobloc sectors disposed in a groove U of the casing E and held in place by a continuous annular ring I^{11} which transmits to an abutment ring F^1 the thrust resulting from the pressure drop of the first stage. From considerations of assembly the ring F^1 may for example be made from a plurality of sectors adjusted and fixed by a ring F^{11} fixed to the ring I^{11} by screws F_1. Sealing of the connection may be obtained either by means of sealing rings or segments Q^1 at the periphery of I^{11} or by arranging for the ring F^{11} to project into the ring F^1.

Fig. 6 shows a modified arrangement for fixing the nozzle blades f_1 of the first stage in the casing E. In this case there is first formed with the blades a complete circumference which is held in a manner already described at its external periphery by means of a ring $I^{11}{}_1$, and an abutment ring $F^1{}_1$ held by a ring $F^{11}{}_1$, and at its inner periphery by means of an abutment ring $I^{11}{}_2$ and an abutment ring $F^1{}_2$ held by a ring $F^{11}{}_2$ in the groove U. Sealing may also be effected by segments such as Q^1 (Fig. 3) not shown in Fig. 6.

Fig. 7 shows a modification of the sealing ring G which in this case includes an annular admission part T which may simplify the formation of the casing E. However, guiding for free expansion is ensured only in a single plane a—a. In this embodiment the nozzle blades f_1 may also be mounted in a single piece (as in the case of Fig. 6 and not in a plurality of sectors as in the case of Fig. 3) and its inner surface rests on the sealing ring G and not in the groove U of the casing E.

In order to effect assembly of the internal structure constituted by the inner casing E and the elements that it contains, the two halves (such as D^1 and D^{11}, Fig. 4) of the largest and last diaphragm D3 are placed on opposite sides of the rotor and joined together along their plane of section between the two last discs R and R3 of the rotor, then the diaphragm D3 thus formed is placed in the circular ring I after the keys such as H have been provisionally located by known means. The operation is repeated for the successive diaphragms such as D and D_2 and for the corresponding rings such as I_2, proceeding towards the admission end. The two halves G^1 and G^{11} of the sealing ring G are then applied to opposite sides of the shaft A. The sealing rings such as Q and W are then put in place, then the last ring I^1 and its abutment ring M are put in place and temporarily held, and the casing E itself is slipped on from the upstream direction towards the downstream direction over the circular rings such as I and the sealing ring G, the casing E having previously been provided as above explained with the nozzle blades f_1 of the first stage. It then remains to place in position and fix, by known means, the fingers K, then to place in position the abutment sections F and to fix the holding ring M to the ring I^1 by means of screws M^1. Each key N, which may be integral with the sealing ring G or has previously been fixed thereto penetrates into its groove N_1 by the open end N_2 thereof (Figs. 3 and 5) at the instant at which the casing E is moved in the downstream direction. The keys N^1 are placed in position in their groove $N^1{}_1$, to complete the operation, at the open ends $N^1{}_2$ of these grooves in which they are fixed by known means.

In the case in which the casing E and the sealing ring G are constructed in the manner illustrated in Fig. 7 assembly is effected in exactly the same way. The ring constituted by the nozzle blades f_1 of the first stage is fixed at its external surface to the casing E as has been explained above, then this casing E is slid over as before in the downstream direction on to the circular rings I and the sealing ring G. The inner surface of the ring constituted by the blades f_1 is of a diameter sufficient to pass over the outer

surface of the sealing ring G constituting the inner wall of the cavity T.

It is now proposed to describe how the internal structure, of which the principle and various forms of construction have just been explained, may be mounted in the interior of the other casings. Fig. 8 is a view in the plane of the horizontal joint of a triple casing E, E^1 and E^{11} and Fig. 9 illustrates the part of the section 9—9 of Fig. 8 included between the plane of the joint 8—8 and the vertical plane 10—10 passing through the axis XX^1 of the machine. The innermost casing E rests through the intermediary of feet such as V_1 and V^1_1 on the plane of the horizontal joint 8—8 of the casing that follows. viz E^1. The feet are grouped in pairs, one of them V_1, ensuring normal repose of the internal casing and thus transmitting to the lower half section of the following casing E^1 a reaction directed downwardly, the other, V^1_1, preventing the rocking of the inner casing and in some cases applying an upwardly directed reaction to the upper half section of this casing E^1. There are, in all, four systems of pairs of feet, located substantially at the ends of the two horizontal generators of the internal casing.

Fig. 10, which is a section of the casings on the vertical plane 10—10 passing through the axis XX^1 of the turbine, shows with Fig. 9 the arrangements made for centering of the internal casing and for locating it longitudinally. The necessary connections are ensured by members contained in the vertical plane of symmetry 10—10; on the one hand by pins Z_1 and Z_2 that fix the transverse plane 9—9 as the origin of the longitudinal expansions of the inner casing within the second casing E^1 and on the other hand by keys Y_1 and Y_2 that centre the internal casing at its other end where they guide its expansion parallel to the axis of the machine. This assembly allows free thermal expansion of the internal casing within the casings surrounding it which with respect to one another are mounted in accordance with similar principles.

WHAT WE CLAIM IS:—

1. An elastic-fluid turbine having an internal casing in one piece enclosing at least the first stages of the turbine and at least one external casing, the stator blades of the turbine being supported in the internal casing by diaphragms each made in at least two sections and mounted in a system of keys which prevent rotation of the diaphragm in the internal casing, each diaphragm being mounted for free expansion in the radial direction and at least one diaphragm bearing in the axial direction against a first ring placed within the internal casing and surrounding the next rotor disc and stator diaphragm downstream, the said first ring bearing in turn against a second ring against which the diaphragm which the said first ring surrounds bears, and the second ring bearing against an abutment removably mounted in the internal casing.

2. A turbine as claimed in claim 1 in which the keys which prevent turning of each diaphragm are attached to the internal casing by fingers which pass freely through the said first ring.

3. A turbine as claimed in claim 2 having seals between the rings and the fingers which hinder leakages of working fluid.

4. A turbine as claimed in any of claims 1 to 3 having seals between the rings and the internal casing which hinder leakages of working fluid.

5. A turbine as claimed in any of the preceding claims in which the nozzle blades of the first rotor stage bear in the axial direction at their outer and/or inner periphery against an abutment ring in one piece which is placed in position by sliding in an upstream direction and attached to the internal casing.

6. A turbine as claimed in any of the preceding claims having an annular admission chamber at least part of the walls of which are in one piece with the internal casing.

7. A turbine as claimed in claim 6 in which the admission chamber is wholly formed in the internal casing, having, in order to prevent losses of working fluid in an upstream direction around the shaft, a sealing ring in two halves which are inserted in an upstream direction to bear against a surface of the internal casing and are held in the internal casing by keys arranged in two transverse planes near the upstream end of the sealing ring in such a way that this can expand freely.

8. A turbine as claimed in claim 6 in which the walls of the admission chamber are formed partly by the internal casing and partly in a sealing ring which prevents the escape of working fluid in an upstream direction around the shaft, the said sealing ring being inserted in an upstream direction to bear against a surface of the internal casing and being held in the internal casing by keys which are arranged in a transverse plane at the upstream end of the sealing ring to prevent it from turning, the nozzle blades of the first stage being mounted at their inner periphery on the sealing ring and at their outer periphery on the internal casing.

9. A turbine as claimed in any of the preceding claims in which the internal casing is mounted in the external casing by means of pins located in the same transverse plane as the radial supply openings of the annular admission chamber of the turbine, the pins serving to fix this plane as the origin for the longitudinal expansion of the internal casing inside the external casing.

10. A steam turbine substantially as des-

cribed with reference to Figs. 3 to 5 of the accompanying drawings.

11. A steam turbine as claimed in claim 10 having the modifications described with reference to Fig. 6 or 7 of the accompanying drawings.

12. A steam turbine as claimed in claim 10 or 11 having the features described with reference to Figs. 8 to 10 of the accompanying drawings.

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Leamington Spa: Printed for Her Majesty's Stationery Office by the Courier Press.—1965.
Published at The Patent Office. 25, Southampton Buildings, London. W.C.2, from which copies may be obtained.

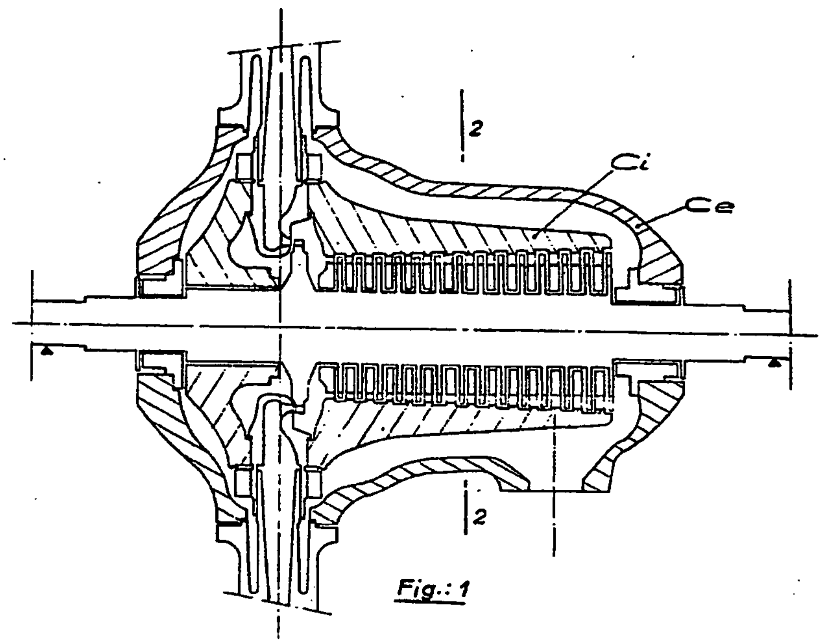

Fig.: 1

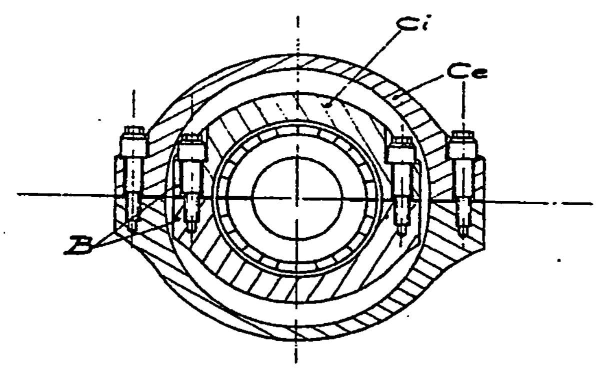

Fig.: 2

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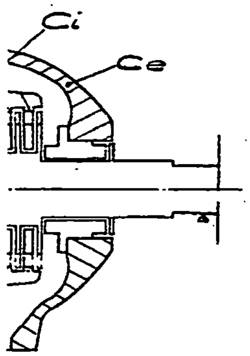


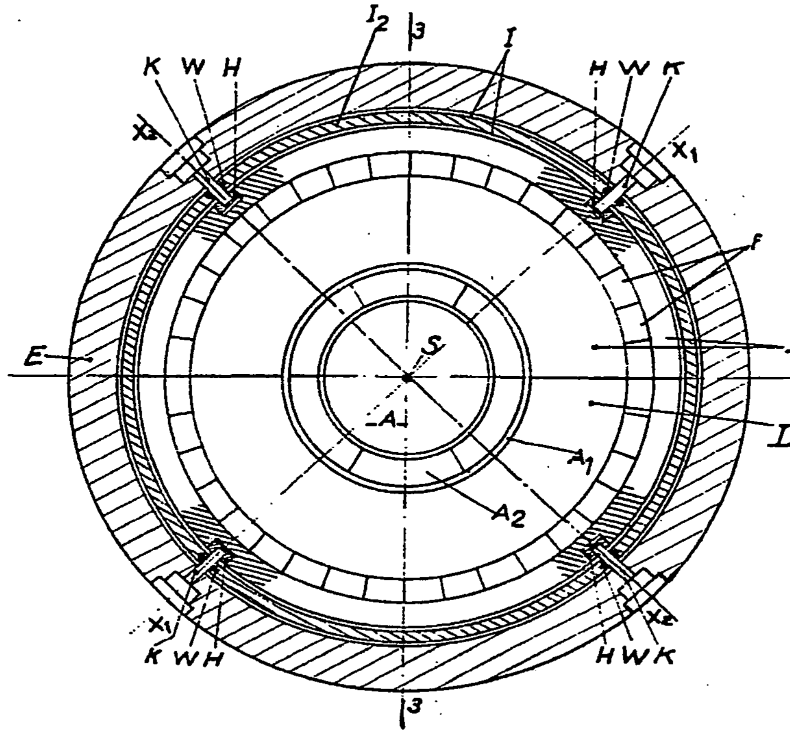
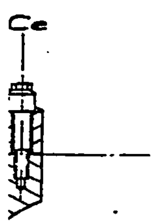


Fig.: 4



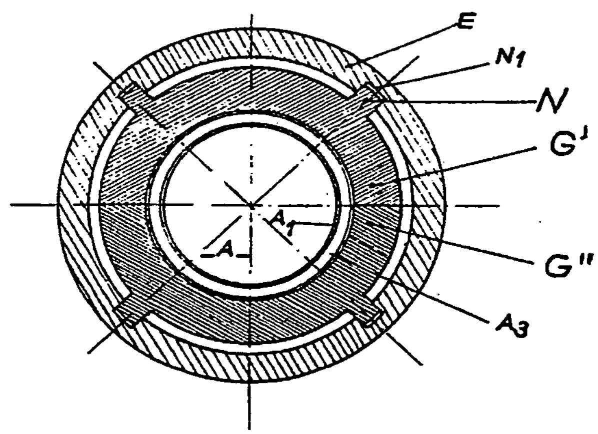


Fig.: 5

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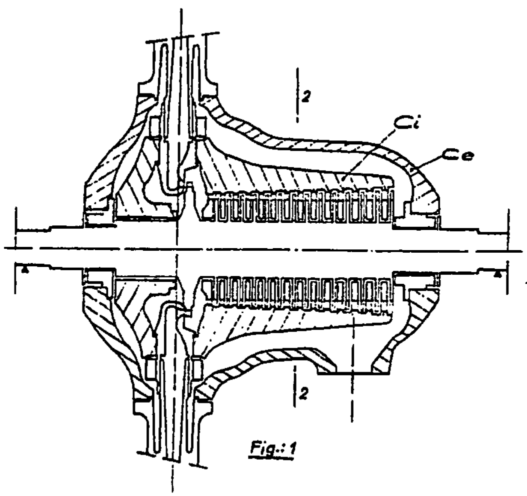


Fig.:1

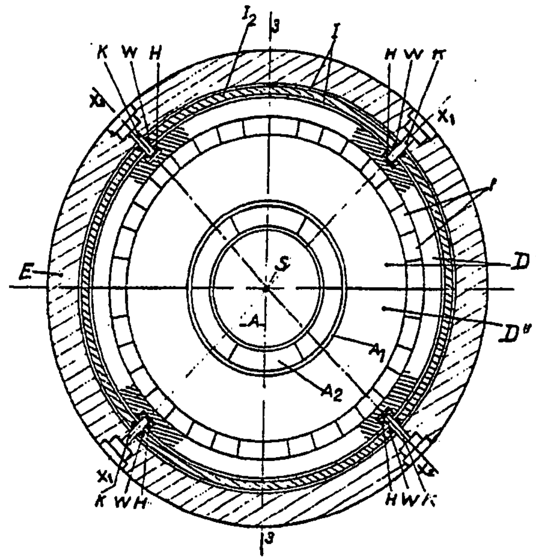


Fig.:4

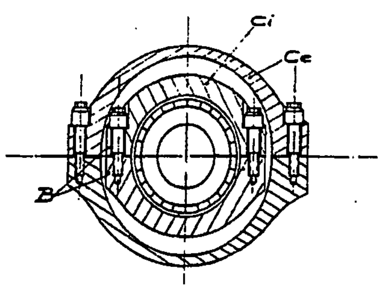
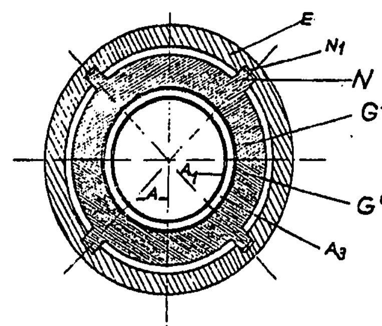


Fig.:2



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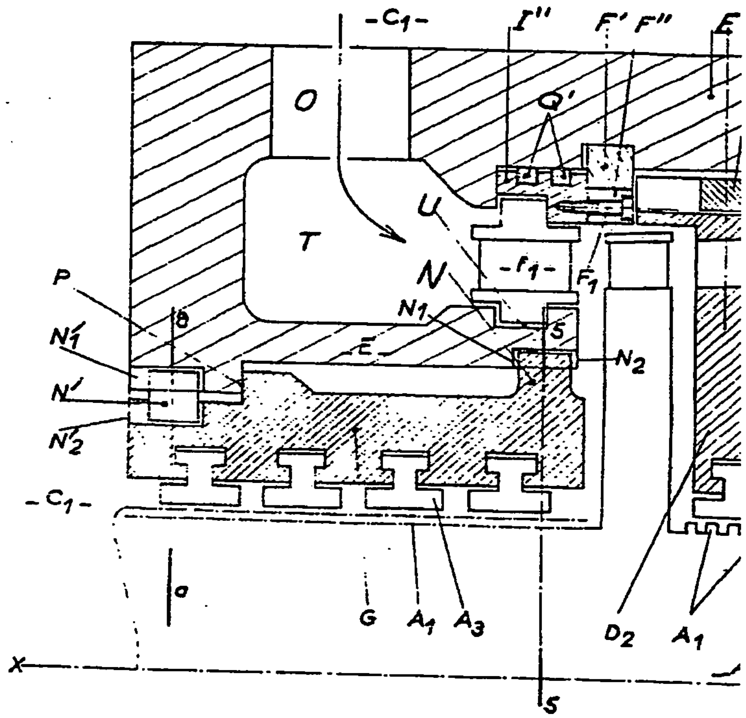
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Fig.

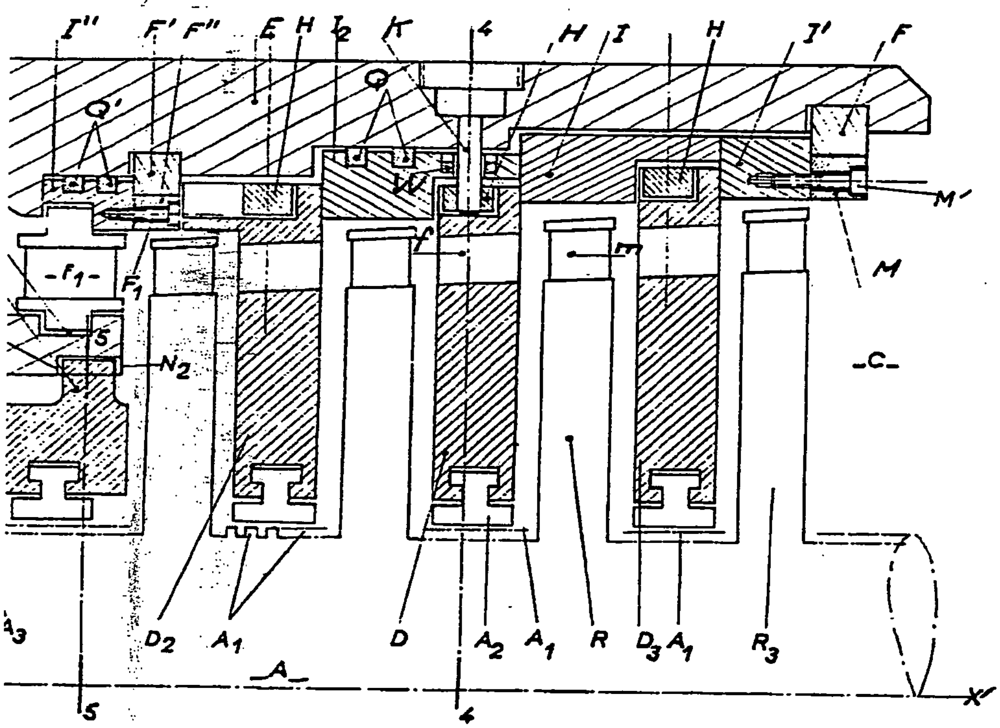
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Fig.:3

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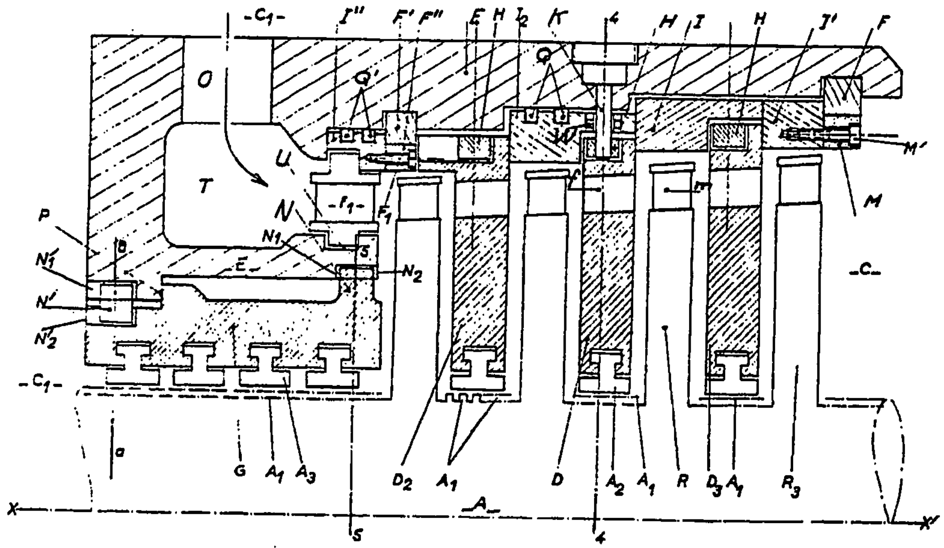

Fig.:3

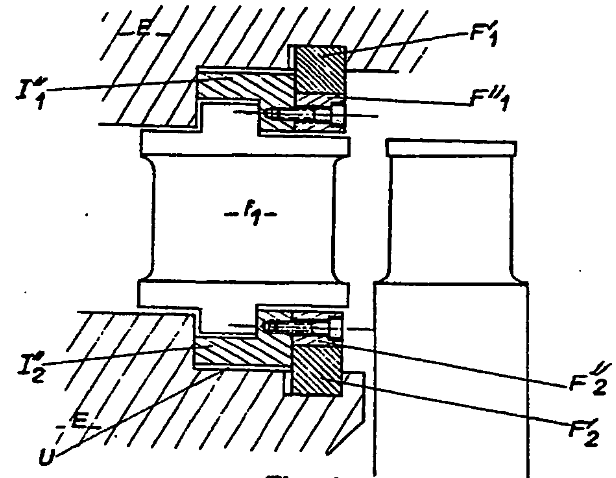

Fig. 6

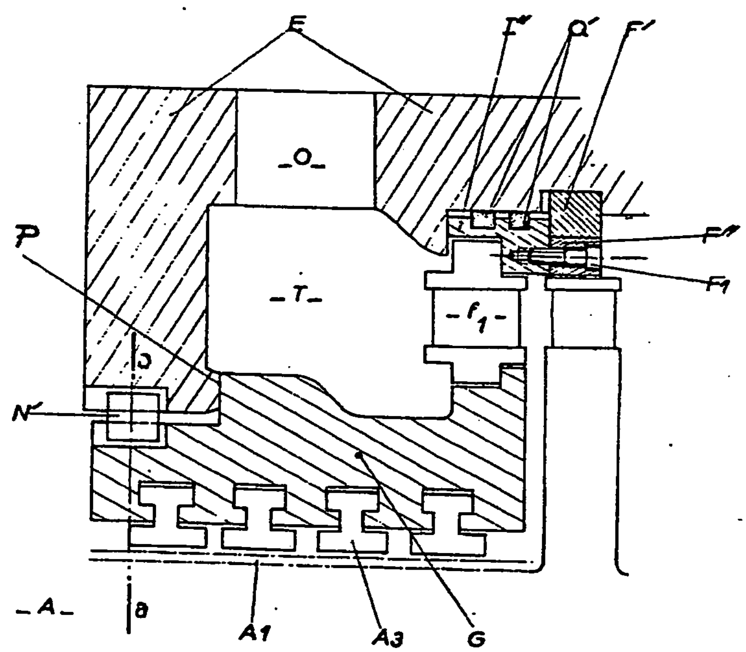

Fig. 7

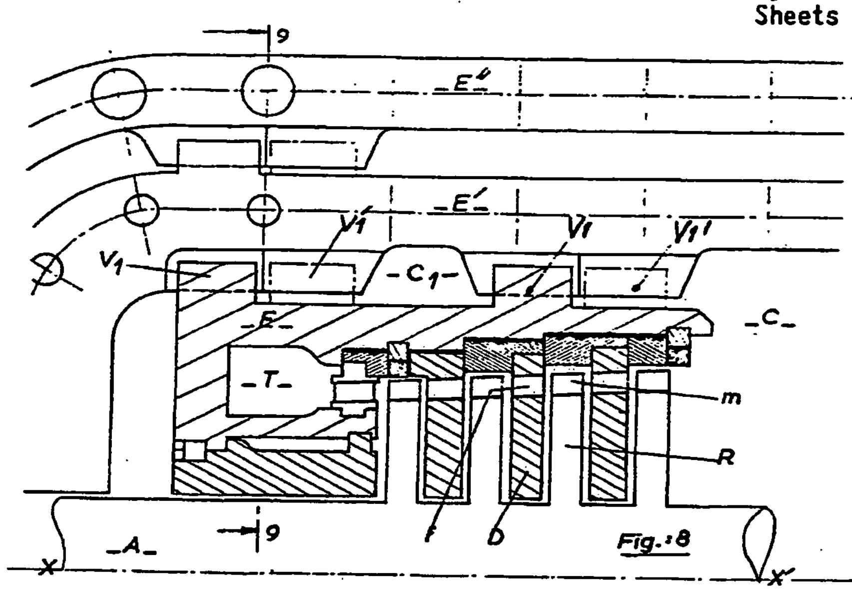
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Fig.:8

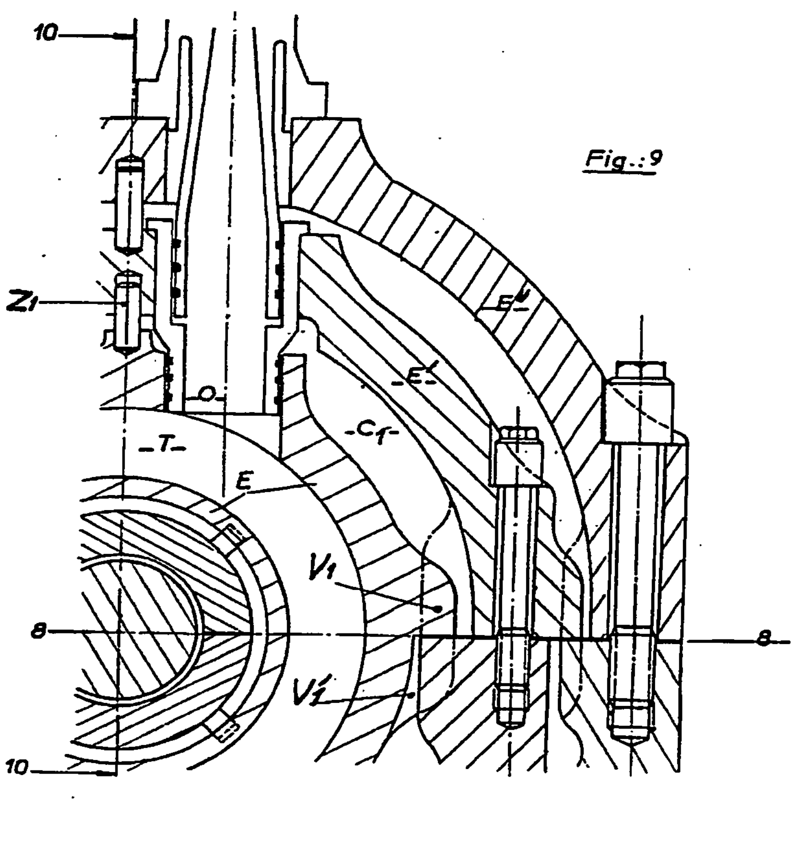
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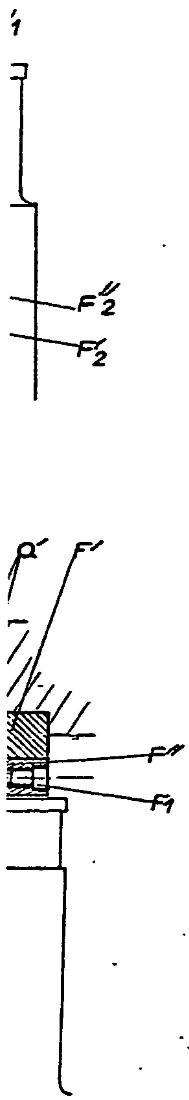
Fig.:9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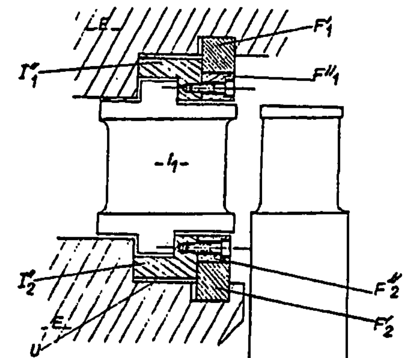


Fig. :6

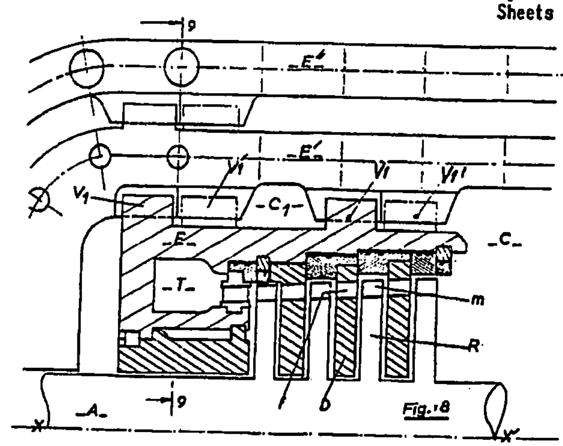


Fig.:8

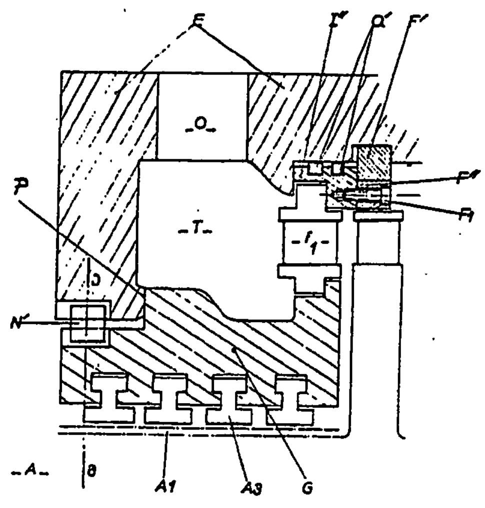
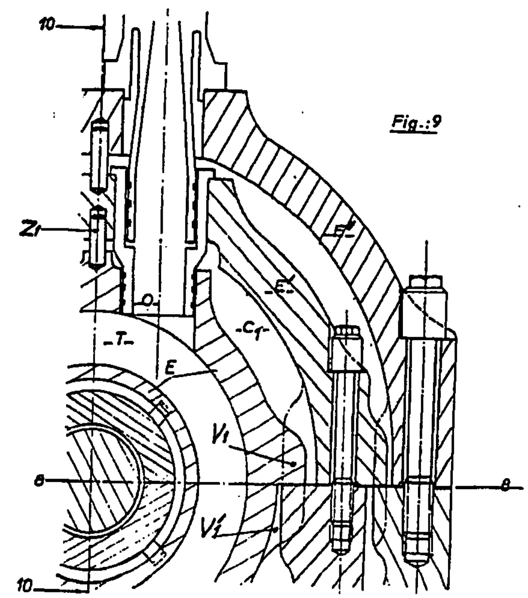


Fig.:7



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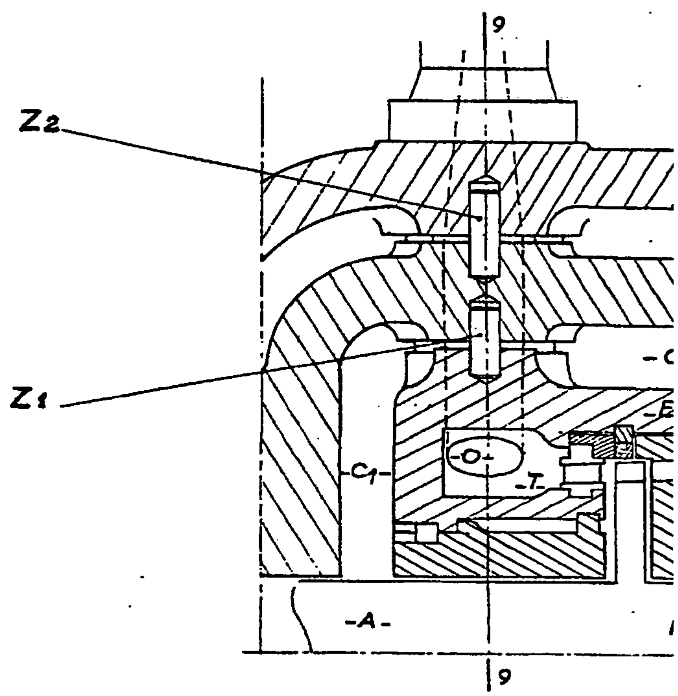
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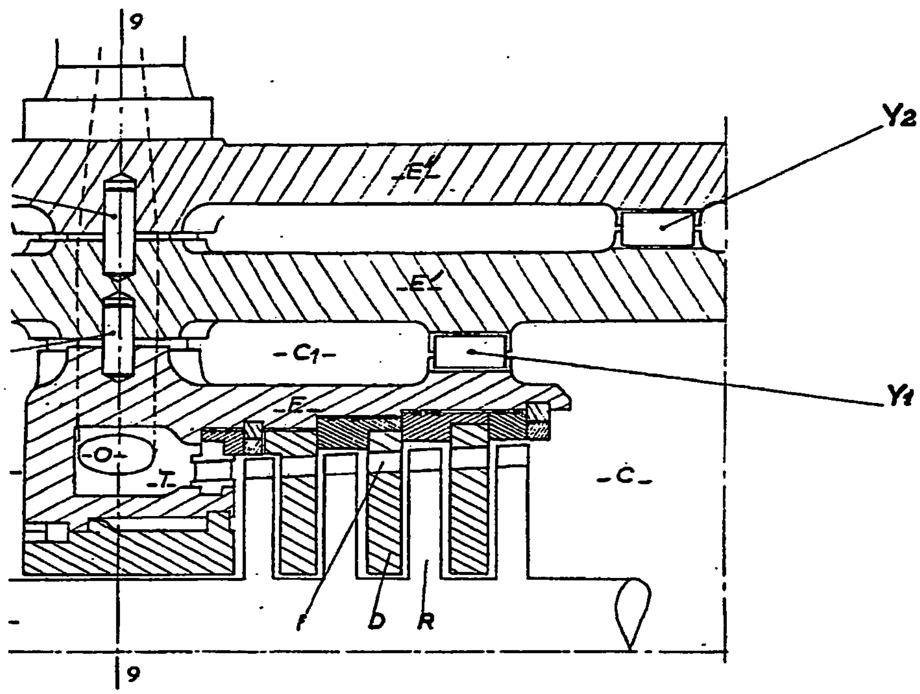

Fig.: 10

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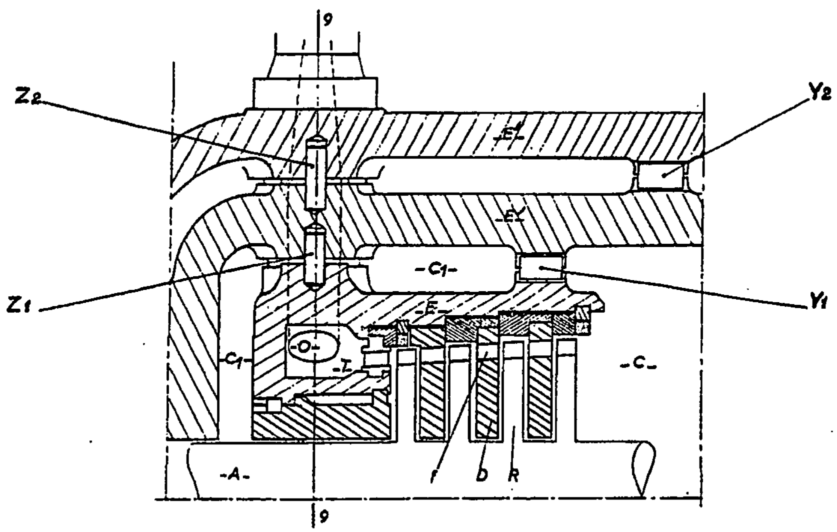

Fig. : 10